

Rapid Assessment of Taal Volcano Protected Landscape (TVPL) Terrestrial Biodiversity*

Jorge Anton D. Ordas^{1,3,5}, Gerald Thomas A. Soliven¹, Arvin C. Diesmos^{1,2}, Rey Donne S. Papa^{1,3,4} and Cecilia I. Banag^{1,3,4}

ABSTRACT

With the exponential rise of human activities in the past decades, majority of studies conducted in Taal Volcano Protected Landscape (TVPL) are geared towards the conservation and preservation of Lake Taal's remaining biodiversity. However, the current structure and assemblage of its terrestrial biotic communities remain relatively unstudied. In this study, we conducted biodiversity censuses in the four sites in TVPL to provide baseline information regarding the community structure of the selected study sites. Comparison of the plant diversity in Taal Volcano Crater Island and Romandan Falls within the forested areas of Mataas na Kahoy, Batangas reveal that both sites support remarkably different vegetation, with the former supporting a smaller floral diversity. The fairly small number of animal samples present difficulty in providing conclusive findings to the wildlife structure of the two study sites. However, the presence of 11 animal species exhibit valuable results in determining the ecological status of TVPL. It is deduced that several ecological barriers exist between the sites, which is attributed to their unique terrestrial biota.

KEY WORDS :

Philippines
Ecology
Biogeography

INTRODUCTION

The Philippines emerged as one of the world's most important biodiversity hotspots (Myers et al., 2000), and is recognized for its complex geological and biogeographical history (Hughes et al., 2015). Thus, its geographical structure makes it a suitable model for investigating processes of diversification within island geographies. By their remote nature, islands in general, are described by limited colonization rates associated with highly unique biodiversity (Weigelt et al., 2015; Kier et al., 2009). However, this theory remains to be tested, as biogeographical data regarding the archipelago is deficient and is represented only by few genera of plants and animals. In this study, the Taal Volcano Protected Landscape (TVPL) was assessed for its terrestrial biota in contribution to the dearth of data regarding the

biogeography of the Philippine archipelago.

The Taal Volcano Protected Landscape (TVPL) is known as a prehistoric volcanic caldera. It was postulated from previous historical phenomena that a depression formed from massive successive faulting and volcanism which led to the settling of a prehistoric volcano. The surrounding lake was known as a result of a complex process where it was linked with the sea in the form of a gulf and was later on detached most likely from organic land turmoil (Babiera & Takahashi, 1997). It houses a diverse assemblage of fauna and flora as a result of freshwater elements and migrants from sea and marine water that thrived in the lake in for a long time. However, studies done in Lake Taal are limited to organisms that inhabit the lake; which leaves the terrestrial flora and fauna basically understudied (Garman, 1863; Herre, 1942; Papa & Mamaril Sr., 2011 and Garcia et al. 2014). The environmental studies of the Tagaytay-Taal Integrated Master Plan in 1994 includes the enumeration of the flora and fauna found within the landscape (PCTT, 1994). Unfortunately, there are no recent published studies that have been made on the distribution and community structures of the terrestrial biota in TVPL. Hence, this study aims to establish baseline information by conducting a rapid biodiversity assessment of its terrestrial biota to augment the limited data available and also, to be able to serve as a springboard for future terrestrial studies in TVPL.

¹ The Graduate School, University of Santo Tomas, España, Manila 1015, Philippines;

² Herpetology Section, Zoology Division, National Museum of the Philippines, Padre Burgos, Manila, Philippines;

³ College of Science, and

⁴ Research Center for the Natural and Applied Sciences, University of Santo Tomas, España, Manila 1015, Philippines

⁵ Correspondence: ordas.jorge@yahoo.com or jdordas@ust.edu.ph

* Article Details

Submitted : 03 September 2016

Accepted : 01 January 2017

MATERIALS AND METHODS

The survey was done on November 20 and 21, 2015 in two locations (Fig. 1) in TVPL; Taal Volcano Island and Romandan falls within the forested areas of Manggahan, Mataas na Kahoy, Batangas. Additional surveys for animals were conducted in Bubuon Island and Napayong Island.

For the plant sampling, a five-hundred (500) meter-long transect line was established at two study sites, in Taal Volcano Island and Romandan falls, Mataas na Kahoy. For every 10 meters of the transect line in alternating intervals, five quadrats (10 m × 10 m) were recognized as areas for survey. All the plants within the quadrat were noted and individual counts were obtained and were treated using Shannon, Dominance and Simpson diversity indices. Representatives were collected and prepared for voucher specimens deposited at the University of Santo Tomas Herbarium (USTH). Identification of the samples was conducted utilizing taxonomic keys and available online resources such as <http://www.philippineplants.org>.

Faunal sampling was limited to reptiles, amphibians, and bats. Opportunistic samplings were conducted during the day and night time for diurnal and nocturnal organisms respectively. For bat collection, multiple mist-nets were placed in various locations. All collected individuals were recorded, photographed, preserved and deposited in the Philippine National Museum.

RESULTS AND DISCUSSION

Floral biodiversity assessment: A total of 47 plant species distributed in 26 families were identified in both Volcano Island and Mataas na Kahoy. There are 13 and 21 families identified for the two sampling sites in Taal Volcano Island and in the forested area, respectively. Table 1 summarizes the diversity indices of the two study sites and Table 2 provides a complete count of all the samples. Results of the calculation of the Simpson's index reveal that the floral composition of the rainforest is less diverse ($D = 0.138$) compared to the Volcano Island ($D = 0.109$). For the computation of Shannon-Weiner Index of diversity, Volcano Island flora yields a higher value ($H = 2.61$) compared to the rainforest ($H = 2.50$). Both sampling sites have high dominance values, indicating several species greatly dominate other plant species. Figure 2 shows several plant species collected from the two sampling sites.

Although the values of Simpson's and Shannon indices demonstrates a lesser diversity for Mataas na Kahoy compared to Volcano Island, a greater representation of plant families are found in the former. The vegetation of the Volcano Island is composed primarily of grasslands, of which talahib (*Saccharum spontaneum*) dominates the study area. Based on observation, weed species *Hedyotis auricularia*

(Fig. 2B), *Mitracarpus hirtus*, and *Euphorbia hirta* and the highly invasive species *Lantana camara* (Fig. 1B) colonize open trails and clearings. Due to the eruptions of the volcano from 1754 to 1965, numerous plant species within the area were easily wiped out, and the current flora within the island are susceptible to imminent eruptions. The forested area is populated by a wider array of flora, from trees, shrubs, vines, and weeds. It is noted that the forest floor is dominated by the weed *Synedrella nodiflora*, resulting to the great disproportion of distribution and the larger value for Shannon index as this value takes into account species evenness. It is interesting to note that the linearity among the three indices when plotted is low ($r < 0.431$). A floristic survey of Volcano Island conducted by the office of PASu-TVPL (unpub.) includes 63 plant species, whereas a recent assessment for the plant species surrounding Taal Lake is still pending. From this, it can be inferred that both sites support entirely different vegetation.

Another principal factor that have shaped the flora of Volcano Island is its proximity between the mainlands. Because the island is an isolated environment in the center of Lake Taal, it is only able to support a lesser variety of plants in contrast to islands much closer to the mainland or in the mainland itself. Natural and human pressures cause alarming rates of local extinctions to occur, and the island's distance and other environmental factors impede the arrival of new plant groups (Kier et al., 2009). The development of agriculture has also brought significant changes in the vegetation cover of the island, whether through landscape modifications or indirectly by long-term shifts in the physical aspects of the site.

Faunal biodiversity assessment: For animals, a total of 4 families of reptiles were represented, namely Gekkonidae, Scincidae, Agamidae and Varanidae. Amphibians were represented by 6 families namely, Ceratobatrachidae, Dicroglossidae, Bufonidae, Microhylidae, Ranidae and Rachophoridae (Table 3). Also one family for bats; Vespertilionidae represented by *Scotophilus kuhlii*. *Gekko gecko* and *Hemidactylus frenatus* were the species observed under the family Gekkonidae. Both are well-known species of geckos and readily encountered in the Philippines, usually in human settlements near exterior lights preying on insects (Kluge, 1969 and Duellman and Pianka, 1990). However, they have different IUCN status, *H. frenatus* has a status of least concern while *G. gecko* has a near threatened status since it is commonly captured to be sold off as pets or Chinese traditional medicine (Sy, 2015). *Varanus marmoratus* represents the family Varanidae. This monitor lizard is frequently found in low land elevations and is known to scavenge food from human habitats or disturbed areas which leads to their exploitation of the species for food, leather or as pets (Konch et al., 2010; Sy, 2015). Its IUCN status is least concern. Agamids were also represented by a *Eutropis sp.*, however it was

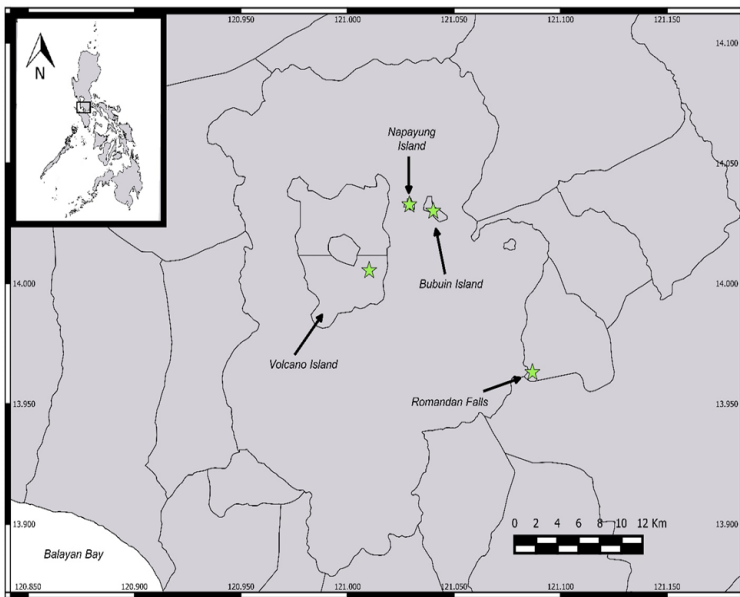


Fig. 1: Sampling sites for floral and faunal survey in TVPL.

Table 1: Plant diversity indices

Sampling Site	Simpson (<i>D</i>)	Shannon (<i>H</i>)	Dominance
Volcano Island	0.109	2.610	0.891
Mataas na Kahoy	0.138	2.500	0.862

not caught. It was observed basking under the sun. Another Agamid, the flying lizard, *Draco spillopterus* was also observed. It is widely distributed in Luzon and Visayas faunal region, this endemic species are frequently encountered in coconut palm plantations and at a lower frequency in secondary growth and primary forests in low elevations. Sample specimens are observed basking high up in a coconut palm tree Romandan falls, Manggahan, Mataas na Kahoy, Batangas. Current IUCN classification for this species is "Data Deficient".

Platymantis mimulus (Fig. 3A) was the only amphibian representative that was not collected. Only its calls "wit-wit" were observed during sampling. This species was originally described by Brown, Alcala and Diesmos (1997) with distribution known from Mount Makiling and its immediate vicinity, on southern Luzon Island, in the Philippines, at around 400m asl. It is commonly called as diminutive forest frog because of its small size. This species is also known to occur in Angat Watershed Reservation in Bulacan Province (McLeod et al., 2011) and in Subic Bay, southern Zambales Province (Devan-Song & Brown, 2012) where they inhabit both pristine and disturbed areas. The IUCN status of this species is near threatened, because although the species is adaptable and appears not to be in decline, its extent of

occurrence is much less than 5,000 km², thus making the species close to qualifying for vulnerable status.

Limnectes woodworthi (Fig. 3B) is widespread in Luzon, Polillo, Palau and Catanduanes Islands, in the northern Philippines. It is commonly encountered in the mountains of Southern Luzon and throughout the Bicol Peninsula (Diesmos, 1998; Alcala & Brown, 1998; Brown et al., 1996; Brown et al., 2013). It is found in lower montane and low-land forests, riverine habitats, and natural and artificial lakes and ponds. It also thrives in disturbed habitats. During the fieldwork, this species was found in riverine areas near Romandan Falls, Manggahan, Mataas na Kahoy. Listed as least concern in the IUCN since, although its extent of occurrence is less than 20,000 km², it is common and adaptable with a presumed large population, and it is unlikely to be declining fast enough to qualify for listing in a more threatened category.

Next is *Rhinella marina* or Cane Toad (Fig. 3C), is a member of the family Bufonidae, a native of central and south America, and was introduced in the Philippines in the 1930s (Alcala & Brown, 1998; Diesmos et al. 2006). Currently, this invasive alien species occur in many areas of the world including most of the major Islands throughout the Philippines except in the Palawan Island Group (Inger, 1954; Alcala & Brown, 1998; Diesmos et al., 2006). *Rhinella marina* are large frogs, growing up to 86 to 132mm SVL (snout-vent length) at maturity, with bufonid bodies and distinct for having a rough dorsum with large tuberculations and two large ovoid parotid glands on their shoulders (Inger, 1954; Alcala, 1986; Alcala & Brown, 1998). This species is common in highly disturbed habitats, occupying forest clearings, but not primary forests (Alcala, 1986; Alcala & Brown, 1998; Diesmos et al., 2006). Similarly, this study reports the presence of *R. marina* in human-disturbed habitats in Volcano Island, where they are found most abundant, and as well as secondary forests in Napayung Island and open areas in Romandan Falls. This species is listed as Least Concern in the IUCN in view of its wide distribution, tolerance of a broad range of habitats, presumed large population, and because it is unlikely to be declining to qualify for listing in a more threatened category. *Kaloula pulchra* (Fig. 3D), also known as Asiatic Painted Narrowmouth Toad, is a member of the anuran family Microhylidae and is believed to be a recent invasive alien species in the Philippines (Diesmos et al., 2006).

The distribution of this species ranged from China, where it was first described, Taiwan, northeastern India and Bangladesh, throughout Indochina, Malay Peninsula, Borneo, Sulawesi, and the Philippines (Ng & Yeo, 2012). *K. pulchra* is a large microhylid, growing up to 75mm (SVL), and distinct from other species for having dilated and truncate finger tips and possessing a characteristically thick, light-brown to orange, irregular band extending behind the eyes down each side of the body (Berry, 1975;

Table 2: Individual counts and relative abundance of plant samples

Site	Family	Species	No. of Individuals	Relative Abundance (%)
Volcano Island	Apocynaceae	<i>Cerbera odollam</i>	27	0.55
	Asteraceae	<i>Bidens sp.</i>	333	6.75
		<i>Mikania cordata</i>	55	1.12
		<i>Synedrella nodifolia</i>	110	2.23
	Cyperaceae	<i>Cyperus sp.</i>	223	4.52
	Euphorbiaceae	<i>Euphorbia sp.</i>	65	1.32
		<i>Euphorbia hirta</i>	427	8.66
		<i>Mallotus sp.</i>	11	0.22
		<i>Bauhinia sp.</i>	28	0.57
	Fabaceae	<i>Delonix sp.</i>	25	0.51
		<i>Leucaena</i>	65	1.32
		<i>Phanera variegata</i>	8	0.16
		<i>Senna alata</i>	27	0.55
	Lamiaceae	<i>Hyptis sp.</i>	87	1.76
		<i>Hyptis brevipes</i>	167	3.39
		<i>Hyptis suaveolens</i>	189	3.83
	Moraceae	<i>Ficus septica</i>	10	0.20
	Piperaceae	<i>Piper nigrum</i>	53	1.07
	Plantaginaceae	<i>Bacopa sp.</i>	183	3.71
	Poaceae	<i>Bambusa sp.</i>	65	1.32
		<i>Saccharum spontaneum.</i>	1250	25.34
		<i>Polygonum perfoliatum</i>	14	0.28
	Rubiaceae	<i>Hedyotis auricularia</i>	526	10.67
		<i>Mitracarpus hirtus</i>	406	8.23
		<i>Oldenlandia corymbosa</i>	206	4.18
		<i>Lantana camara</i>	372	7.54
	Verbenaceae			
TOTAL			4932	100

Cont'd. Table 2

Site	Family	Species	No. of Individuals	Relative Abundance (%)
Mataas na Kahoy	Apocynaceae	<i>Cerbera odollam</i>	6	0.44
	Araceae	<i>Alocasia sp.</i>	49	3.60
	Arecaceae	<i>Cocos nucifera</i>	59	4.33
	Asteraceae	<i>Ageratum conyzoides</i>	206	15.12
		<i>Synedrella nodifolia</i>	405	29.74
	Basellaceae	<i>Basella alba</i>	55	4.04
	Caricaceae	<i>Carica papaya</i>	39	2.86
	Commelinaceae	<i>Polia secundiflora</i>	9	0.66
	Costaceae	<i>Costus speciosus</i>	34	2.50
	Dioscoreaceae	<i>Dioscorea sp.</i>	32	2.35
	Euphorbiaceae	<i>Euphorbia hirta</i>	167	12.26
		<i>Macaranga sp.</i>	33	2.42
		<i>Mallotus sp.</i>	30	2.20
	Garryaceae	<i>Aucuba sp.</i>	3	0.22
	Lamiaceae	<i>Plectranthus scutellarioides</i>	28	2.06
	Malvaceae	<i>Corchorus sp.</i>	46	3.38
		<i>Hibiscus sp.</i>	12	0.88
	Moraceae	<i>Ficus septica</i>	10	0.73
	Musaceae	<i>Musa sp.</i>	25	1.84
	Piperaceae	<i>Piper nigrum</i>	18	1.32
	Poaceae	<i>Centotheca sp.</i>	10	0.73
	Rubiaceae	<i>Coffea Arabica</i>	5	0.37
		<i>Nauclea orientalis</i>	8	0.59
	Verbenaceae	<i>Clerodendrum</i>	51	3.74
	Vitaceae	<i>Tetrastigma sp.</i>	3	0.22
	Zingiberaceae	<i>Zingiber zerumbet</i>	19	1.40
TOTAL			1362	100

Table 3: Species Profile of Amphibians and Reptiles Collected and Observed

	Locality	IUCN Status	Remarks
REPTILIA			
Gekkonidae			
<i>Gekko gecko</i> (Linnaeus 1758)	Volcano Island	Near Threatened	Juvenile, sub adult & adult individuals were observed
<i>Hemidactylus frenatus</i> Duméril & Bibron 1836	Volcano Island & Romandan Falls	Least Concern	
Varanidae			
<i>Varanus marmoratus</i> (Wiegmann, 1834)	Romandan Falls	Least Concern	Heavily infested with ticks
Scincidae			
<i>Eutropis sp.</i>	Romandan Falls	N/A	Was not caught but observed basking
Agamidae			
<i>Draco spilopterus</i> (Wiegmann, 1834)	Romandan Falls	Not Assessed	Was not caught
AMPHIBIA			
Ceratobatrachidae			
<i>Platymantis mimulus</i> Brown, Alcala & Diesmos, 1997	Romandan Falls	Near Threatened	Not caught, but call was heard "wit-wit"
Dicroglossidae			
<i>Limnonectes woodworthi</i> (Taylor, 1923)	Romandan Falls	Least Concern	
Bufonidae			
<i>Rhinella marina</i> (Linnaeus, 1758)	Volcano Island & Romandan Falls	Least Concern	
Microhylidae			
<i>Kaloula pulchra</i> Gray, 1831	Romandan Falls	Least Concern	
Ranidae			
<i>Hylarana erythraea</i> Schlegel, 1837	Romandan Falls	Least Concern	
Rhacophoridae			
<i>Polypedates leucomystax</i> (Gravenhorst, 1829)	Romandan Falls	Least Concern	



Fig. 2: Different plant species found in Volcano Island in Lake Taal. A-E Volcano Island flora. F-J Mataas na Kahoy flora. A. *Lantana camara* B. *Hedyotis auricularia* C. *Hyptis suaveolens* D. *Bauhinia* sp. E. *Mikania cordata* F. *Alocasia* sp. G. *Tetrastigma* sp. H. *Clerodendrum* sp. I. *Costus speciosus* J. *Coffea arabica*

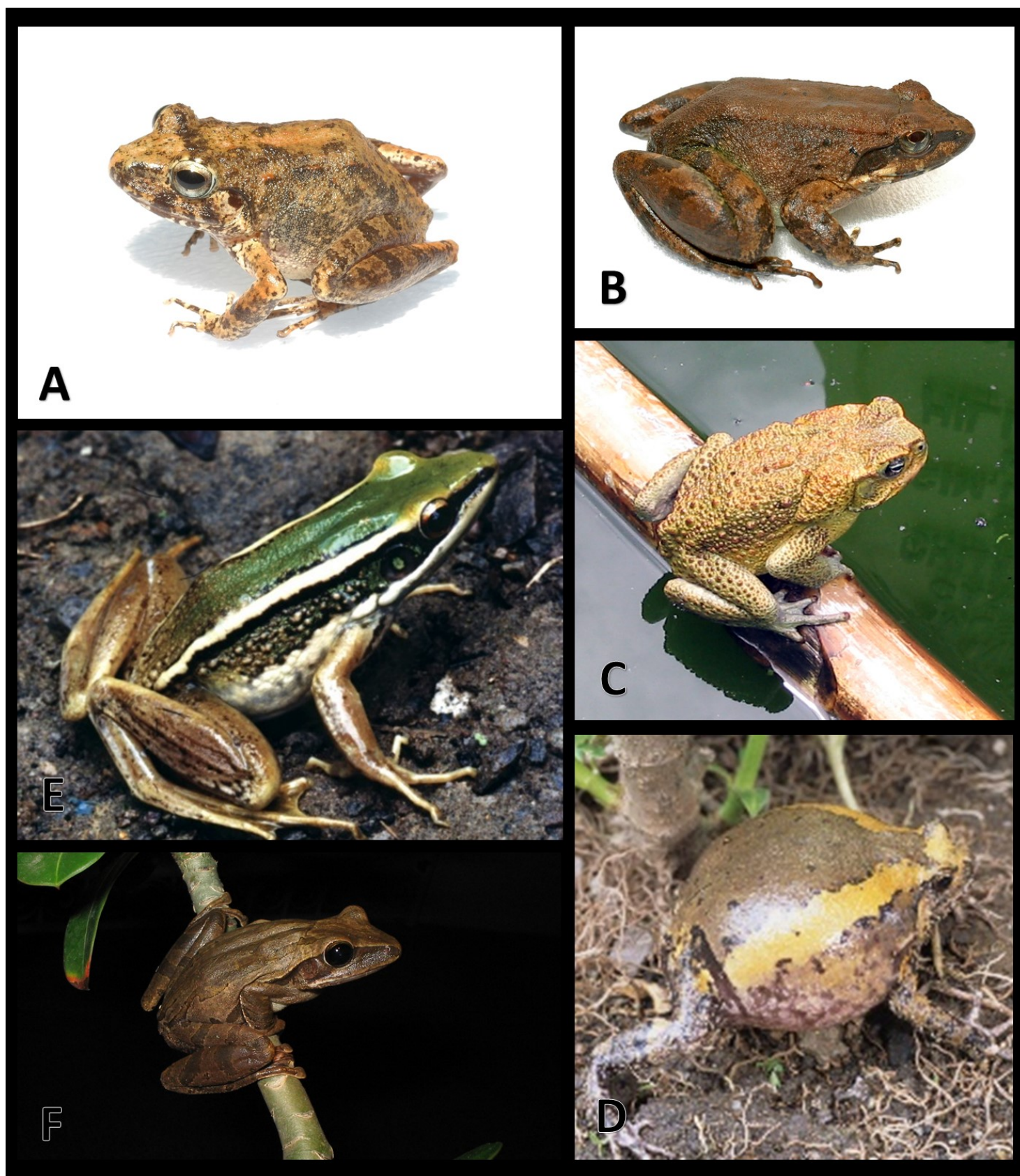


Fig. 3: Frog and toad species found in the TVPL. A. *Platymantis mimulus* Brown, Alcalá & Diesmos 1997 B. *Limnonectes woodworthi* Taylor 1923 C. *Rhinella marina* Linnaeus (1758) D. *Kaloula pulchra* Gray 1831 inflated E. *Hylarana erythraea* Schlegel 1837 F. *Polypedates leucomystax* Gravenhorst, 1829 observed in microhabitat, hanging on a branch. Photos taken by Arvin C. Diesmos.

Sengupta et al., 2009). This species inhabit secondary and primary forest habitats, in lakes and ponds with aquatic vegetation, near forest trails, logged paddy fields, and around human habitation (Sengupta et al., 2009). This study reports the occurrence of *K. pulchra* in the Taal Lake Conservation Center (TLCC) compound, Mataas na Kahoy, Batangas. This species is listed as least concern in view of its wide distribution, tolerance of a broad range of habitats, presumed large population, and because it is unlikely to be declining to qualify for listing in a more threatened category.

Hylarana erythraea (Fig. 3E) also known as common green frog, is a member of the anuran family Ranidae and a speculated invasive alien species in the Philippines due to its disjunct distribution (Inger, 1996; Diesmos et al., 2006). It has a wide distribution ranging from Java, Borneo, Vietnam, and Thailand through Burma to West Bengal and Orissa, India including Philippines where it is believed to be widespread (Diesmos et al., 2014). This ranid species are small to moderately large frogs growing up to 77mm at maturity. This species is distinct for having a dorsolateral stripe that runs from eye to leg and characterized by its distinctive pattern of broad cream center with broad dark brown to black borders on either side. *H. erythraea* are typically observed in the vicinity of water, in ponds, rice fields, and other aquatic habitats with little or no current (Inger, 1954). Similarly, this study reports the occurrence of *H. erythraea* in narrow streams of Romandan Falls, Taal, where four individuals were observed perched on semi-aquatic vegetation along the water periphery. This species is listed as least concern in IUCN in view of its wide distribution, tolerance of a broad range of habitats and presumed large population.

Polypedates leucomystax is a rhacophorid frog (Fig. 3F) is arboreal and could be found in residential and disturbed areas as long as there are Banana plants and a water system below the plants. According to a study by Brown et al. (1996), this species may be brought to the archipelago by humans by means of agricultural and forest products. This species was collected in a Banana plant near Romandan Falls, Manggahan, Mataas na Kahoy, Batangas at night time. This species is listed as least concern in view of its wide distribution, tolerance of a broad range of habitats, presumed large population, and because it is unlikely to be declining fast enough to qualify for listing in a more threatened category.

For bats, only five individuals of one species were caught by the mist-nets. It was identified to be *S. kuhlii*, an adaptable species is relatively found in primary and secondary habitats, and in both rural and urban areas, also it is an early flyer and prefers to feed on hymenopterans and dipterans (Bates et al., 2008). It is a widely distributed species and it ranges through much of South Asia, southern China and Southeast Asia. However, in the Philippine archipelago, it is recorded present throughout much of the country, from Luzon, Visayas and Mindanao and occurs from sea level to 600m (Srinivasulu et al., 2010).

CONCLUSIONS AND RECOMMENDATIONS

The low number of samples for animal specimens presents difficulty in providing insights to the wildlife biogeography of the study site. However, they exemplify valuable results in determining the ecological status of TVPL. It is observed that the two study sites bear different flora compositions. Primarily, past eruptions, increased human activities, and Volcano Island's isolation in the center of Lake Taal possibly formed several ecological barriers that hinder dispersal of other plant species to the remote island. This rapid terrestrial biodiversity assessment of TVPL should contribute to future ecological and island biogeographical studies, in determining the factors that drive the evolutionary patterns of the Philippine biota.

ACKNOWLEDGEMENTS

We would like to thank the Biogeography Class (2015-2016) of the UST Graduate School for helping collect specimens. This project was funded by the Partnerships for Enhanced Engagement in Research (PEER) Science Grant awarded by the US National Academy of Science and USAID (Sub Grant No. PGA-2000004881; AID-OAA-A-11-00012 2014-2016).

LITERATURE CITED

- Alcala, A.C & W.C. Brown, 1998. *Philippine Amphibians: an Illustrated Field Guide*. Bookmark Press, Makati City, Philippines. 116 pp.
- Babiera, V.V. & T. Takahashi, 1997. Characteristics of soils derived from tephra and pyroclastic flow deposits from Taal volcano, the Philippines. *Soil science and plant nutrition*, 43(4): 763-776.
- Bates, P., T. Kingston, C. Francis, G. Rosell-Ambal, L. Heaney, J.C. Gonzales, S. Molur & C. Srinivasulu, 2008. *Scotophilus kuhlii*. In: IUCN. (2008). IUCN Red List of Threatened Species. Retrieved 2015-08-07.
- Berry, P.Y., 1975. *The Amphibian Fauna of Peninsular Malaysia*. Tropical Press, Kuala Lumpur. 130 pp.
- Brown R.M., J.W. Ferner, R.V. Sison, P.C. Gonzales, & R.S. Kennedy, 1996. Amphibians and reptiles of the Zambales mountains of Luzon Island, Philippines. *Herpetological Natural History*, 4: 1-17.
- Brown, W.C., A.C. Alcala, & A.C. Diesmos, 1997. A new species of the genus *Platymantis* (Amphibia: Ranidae) from Luzon Island, Philippines. *Proceedings of the Biological Society of Washington*: 18-23.
- Brown, R. M., C.D. Siler, C.H. Oliveros, L.J. Welton, A. Rock, J.C. Swab, & A.C. Diesmos, 2013. The amphibians and reptiles of Luzon Island, Philippines, VIII: the herpetofauna of Cagayan and Isabela Provinces, northern Sierra Madre Mountain Range. *ZooKeys*, 266: 1-120.

- Devan-Song, A. & R. M. Brown, 2012. Amphibians and reptiles of Luzon Island, Philippines, VI: The herpetofauna of the Subic Bay area. *Asian Herpetological Research*, 3 (1), 1–20.
- Diesmos AC, 1998. The Amphibian Faunas of Mt. Banahao, Mt. San Cristobal, and Mt. Maquiling, Luzon Island, Philippines. MS thesis, University of the Philippines at Los Baños, College, Laguna, Philippines. 115 pp.
- Diesmos A.C., M.L. Diesmos, & R.M. Brown, 2006. Status and Distribution of Alien Invasive Frogs in the Philippines. *Journal of Environmental Science and Management*, 9:2.
- Diesmos, A.C., A.C. Alcala, C.D. Siler, & R.M. Brown, 2014. Conservation Biology of Amphibians of Asia; Status of Conservation and Decline of Amphibians: Eastern Hemisphere ed. by H Heatwole and I. Das. Natural History Publications (Borneo), Kota Kinabalu. Vol. 11: 1. pp 396.
- Duellman, W.E., & E.R. Pianka, E.R, 1990. Biogeography of Nocturnal Insectivores: Historical Events and Ecological Filters. *Annual Review of Ecology and Systematics*, 2: 57-68.
- Garman, S., 1863. New and little-known reptiles and fishes in the museum collections. *Bulletin of the Museum of Comparative Zoology*, 8(3): 85-93.
- Herre, A.W., 1942. Notes on Philippine sea-snakes. *Copeia*, 7 -9.
- Hughes, M., R. Rubite, P. Blanc, K. Chung, & C. Peng, 2015. The Miocene to Pleistocene colonization of the Philippine archipelago by *Begonia* sect. *Baryandra* (Begoniaceae). *American Journal of Botany* 102(5): 695-706.
- Inger R.F., 1954. Systematics and zoogeography of Philippine Amphibia. *Fieldiana: Zoology*, 33: 183-531
- Inger R.F. & F.L. Tan, 1996. Checklist of the frogs of Borneo. *Raffles Bulletin of Zoology*, 44: 551-574.
- Kier, G., H. Kreft, T.M. Lee, W. Jetz, P.L. Ibisch, C. Nowicki, J. Mutke & W. Barthlott, 2009. A global assessment of endemism and species richness across island and mainland regions. *Proceedings of the National Academy of Sciences of the United States of America*, 106(23): 9322–9327.
- Myers, N., R. Mittermeier, C. Mittermeier, G. Fonseca, J. Kent, 2000. Biodiversity hotspots for conservation priorities. *Nature* 403: 853-858.
- Papa, R. D. S., & A.C. Mamaril Sr, 2011. History of the biodiversity and limno-ecological studies on Lake Taal with notes on the current state of Philippine limnology. *Philippine Science Letters* 4: 1-10.
- Kluge, A.G., 1969. The evolution and geographical origin of the New World *Hemidactylus mabouia* complex (Gekkonidae, Sauria). *Miscellaneous Publications of Zoology, University of Michigan*, 138:1-78.
- Koch, A., M. Gaulke & W. Böhme, 2010. Unravelling the underestimated diversity of Philippine water monitor lizards (Squamata: *Varanus salvator* complex), with the description of two new species and a new subspecies. *Zootaxa*, 2446: 1-54.
- McLeod, D. S., C.D. Siler, A.C. Diesmos, M.L.L. Diesmos, V.S. Garcia, A.O. Arkonco, & R. M. Brown, 2011. Amphibians and Reptiles of Luzon Island, V: The Herpetofauna of Angat Dam Watershed, Bulacan Province, Luzon Island, Philippines. *Asian Herpetological Research*, 2(4), 177–198.
- Ng T.H. & D.C.J. Yeo, 2012. Non-Indigenous Frogs In Singapore. *Nature in Singapore*, 5: 95-102.
- DENR-PASu-TVPL Office. *Plant species recorded in Taal Volcano Island*. Talisay, Batangas.
- PCCT. The Tagaytay-Taal integrated master plan. 20-year plan. Manila: Department of Tourism. 1994.
- Sengupta S., A. Das, S. Das, B. Hussain, N.K. Choudhury, & S.K. Dutta, 2009. Taxonomy and biogeography of *Kaloula* species of Eastern India. *The Natural History Journal of Chulalongkorn University*, 9(2): 209-222.
- Srinivasulu, B., C. Srinivasulu, & P. Venkateshwarlu, 2010. First record of lesser yellow house bat *Scotophilus kuhlii* Leach, 1821 from Secunderabad, Andhra Pradesh, India with a note on its diet. *Journal of Threatened Taxa*, 2(10): 1234-1236.
- Sy, E., 2015. Checklist of Exotic Species in the Philippine Pet Trade, II. Reptiles. *Journal of Nature Studies*, 14 (1): 66-93.
- Weigelt, P., D. Kissling, Y. Kisel, S. Fritz, D. Karger, M. Kessler, S. Lehtonen, J. Svenning, & H. Kreft, 2015. Global patterns and drivers of phylogenetic structure in island floras. *Nature Scientific Reports*: 1-13.
- Zahl, S., 1977. Jackknifing an index of diversity. *Ecology*, 907-913.